arXiv:cond-mat/0605502v1 [cond-mat.stat-mech] 20 May 2006

Published in **Europhysics News 37/2 (2006) 10**

Reply to the Comment by T. Dauxois, F. Bouchet, S. Ruffo on the paper by A. Rapisarda and A. Pluchino, Europhysics News, 36 (2005) 202

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(Dated: February 6, 2008)

In the comment by T.Dauxois et al. [1] the authors question our application of nonextensive statistical mechanics proposed by Tsallis [2] and discussed in [3] to explain the anomalous dynamics of the Hamiltonian Mean Field (HMF) model. More specifically they claim that the explanation of the metastability found in the out-of-equilibrium dynamics is only a fitting procedure and is also in contrast with a previous application done in ref. [4]. This criticism mostly relies on recent studies based on the Vlasov approach and discussed in refs. [5, 6], where the authors claim to explain the anomalous behaviour of the HMF model in terms of a standard formalism. In order to reply to this comment we want to stress a few numerical facts and conclude with some final considerations.

(i) In our numerical simulations we consider always a *finite* number of particles, which plays the role of a collision term absent in the Vlasov equation. This collision term is very important since it drives the systems towards the equilibrium.

(ii) In our paper [3], we use a *finite* initial magnetization which leads to a violent thermal explosion. The quasi-stationary state which follows is microscopically nonhomogeneous, with a hierarchical cluster size distribution [7]. The Vlasov-like approach proposed in [5] has severe problems in dealing with these inhomogeneities. Up to now all the derivations presented in the literature start from a homogenous metastable state, where no violent relaxation occurs [8]. In this case, the decay of the velocity correlation function is very fast (almost exponential), in remarkable contrast to what observed for an intial finite magnetization, where a q-exponential (with $q > 1$) is found [3, 8].

(iii) The predictions of Tsallis thermostatistics [2] are successfully compared with the numerical results, as shown in figs.3,4 of ref. [3]. In this case, it is not true that we perform simply a fit of numerical data. By means of Tsallis statistics and using q-exponentials to reproduce extremely well the anomalous diffusion behaviour, we can predict the correlation decay with great precision and viceversa. At variance, the results of the approach proposed by Dauxois et al. [5] have not been tested with numerical simulations, so that no real prediction can reasonably be claimed.

(iv) The results presented in [3] are *not* in contradiction with previous papers since they refer to velocity correlations decay and *not* to the marginal velocity probability density functions discussed in [4], where the entropic index extracted was only an effective one and indicated a strong departure from a Gaussian shape. On the other hand, the possible application of Tsallis statistics in long-range Hamiltonian systems is confirmed by several other studies [9].

In conclusion the HMF model is a paradigmatic example of a large class of long-range Hamiltonian systems which have important physical applications, ranging from self-gravitating systems to plasmas. The nonhomogeneous metastability observed for the HMF model goes *undoubtedly* beyond standard Boltzmann-Gibbs statistical mechanics and has a dynamical origin, therefore a new kind of kinetics should be used [10]. In general, adopting different perspectives is a useful procedure to shed light on a tricky problem. Tsallis statistics is a good candidate to explain and interpret the strange behaviour of long-range Hamiltonian systems, and this is *not* in contradiction with other possible formalisms, including that one of Dauxois et al. (analogously the Langevin and the Fokker-Planck phenomenological formulations are *not* in contradiction with Boltzmann-Gibbs statistical mechanics). We have also successfully applied techniques normally used for glassy systems [7], and interesting connections with Kuramoto model and the synchronization problem have been advanced [8]. In any case further work is needed to understand in detail this intriguing new field.

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